DESTRUCTION AND CORROSION of CONCRETE AND STEEL

1. Corrosion and Passivation of Steel Reinforcement

Exposed steel will corrode in moist atmospheres due to differences in the electrical potential on the steel surface forming anodic and cathodic sites. The metal oxidises at the anode where corrosion occurs according to:

$$Fe\ (metal) \rightarrow Fe^{2+}\ (aq.) + 2e^-$$

Simultaneously, reduction occurs at cathodic sites, typical cathodic processes being:

$$\tfrac{1}{2}O_2 + H_2O + 2e^-(metal) \rightarrow 2OH^-(aq.)$$

$$2H^+(aq.) + 2e^-\ (metal) \rightarrow H_2(gas)$$

The electrons produced during this process are conducted through the metal whilst the ions formed are transported via the pore water which acts as the electrolyte.

Concrete as an Environment

The environment provided by good quality concrete to steel reinforcement is one of high alkalinity due to the presence of the hydroxides of sodium, potassium and calcium produced during the hydration reactions. The bulk of surrounding concrete acts as a physical barrier to many of the steel's aggressors. In such an environment steel is passive and any small breaks in its protective oxide film are soon repaired. If, however, the alkalinity of its surroundings are reduced, such as by neutralisation with atmospheric carbon dioxide, or depassivating anions such as chloride are able to reach the steel then severe corrosion of the reinforcement can occur. This in turn can result in to staining of the concrete by rust and spalling of the cover due to the increase in volume associated with the conversion of iron to iron oxide.

Factors Affecting Corrosion Rates of Steel in Concrete

The factors which determine the corrosion rate of steel in concrete are; the presence of an ionically conducting aqueous phase in contact with the steel (i.e. pore water), the existence of anodic and cathodic sites on the metal in contact with this electrolyte and the availability of oxygen to enable the reactions to proceed.

The permeability of the concrete is important in determining the extent to which aggressive external substances can attack the steel. A thick concrete cover of low permeability is more likely to prevent chloride ions from an external source from reaching the steel and causing depassivation.

Alternatives for the Reinforcing Phase

Where an adequate depth of cover is difficult to achieve due to design considerations or where aggressive environments are expected such as in marine structures or bridge decks, additional protection may be required for the embedded steel. This may take many and varied forms and commercial interest in this field is strong. The steel reinforcement itself may be made more able to maintain its passivity by providing it with a protective coating such as zinc, epoxy resin or stainless steel cladding. In extreme circumstances, solid stainless steel reinforcements may be used, although the perceived additional cost restricts its use in all but the most specialized applications.

The Ideal Situation

There can be little doubt that the most effective way of protecting steel which is embedded in concrete is to provide it with an adequate depth of cover by high strength, low permeability concrete free from depassivating ions such as chlorides. However, in the real world, concrete is laid by the tonne in all weathers and environments, exposed to industrial atmospheres, de-icing salts and seawater.

The Real Situation

Contaminated materials and poor workmanship are hard to avoid completely but by understanding the often complex chemical and electrochemical conditions that can exists it should be possible to develop ways of producing structures which will last long into the next century.

2. Deterioration Mechanisms

The majority of reinforced concrete around the world performs adequately and gives few problems. A minority of structures have deteriorated due to either the action of aggressive components from the external environment or incompatibility of the mix constituents. Problems can arise as a result of incomplete or inaccurate site investigation, poor design, badly specified concrete, poor workmanship and a range of other factors.

Stages of Deterioration

The mechanisms of deterioration are primarily chemico-physical in nature (i.e. a chemical reaction with the formation of products greater in volume than the reactants producing physical effects such as cracking and spalling) and occur in three discrete stages:

- Stage 1: Initiation (t0) – Concentration of aggressive species is insufficient to initiate any chemical reactions or the chemical reaction is occurring very slowly. No physical damage has occurred. The duration of t0 may vary from a few minutes to the design life of the structure.

 Stage 2: Propagation (t1) – Chemical reactions begin or are continuing, some physical damage may occur but is insufficient to cause distress. Acceleration of the deterioration process usually occurs during this stage due to increased accessibility of aggressive ions or modification of the concrete environment.

 Stage 3: Deterioration (t2) – Rapid breakdown of the fabric of the structure. The combined effects of the physical and chemical processes are of sufficient severity that the structure is no longer serviceable (failure occurs) and major remedial work or, in extreme cases, demolition is required.

Modes of Deterioration

Deterioration may occur due to a number of mechanisms on which a large body of literature already exists. These include:

 Corrosion of reinforcement, due to:

- Chloride ions.
- Carbonation.
- Change in the rebar environment (impinging cracks).

 Sulphate attack of concrete.

 Salt recrystallisation (exfoliation)

 Soft water/acid attack of concrete.

 Alkali Aggregate Reaction (AAR).

 Thermal incompatibility of concrete components (TICC).

 Shrinkage.

 Frost Damage

All these factors must be considered during design and specification.

3.Factors Influencing Rates of Deterioration

The environment provided by good quality concrete for the embedded steel reinforcement is one of high alkalinity (generally >pH 13), produced by the hydroxides of sodium, potassium and calcium released during the various hydration reactions. In addition, the bulk of surrounding concrete acts as a physical barrier to most of the substances that may lead to degradation of the reinforcement.

Provided this environment is maintained, the steel remains passive and any small breaks in the stable protective oxide film are soon repaired. However, if the alkalinity of the surroundings is reduced, for example by reaction with atmospheric carbon dioxide (carbonation), or if depassivating chloride ions are made available at the surface of the steel then corrosion may be initiated, resulting in loss of steel section and spalling of cover.

Depth of Cover

Inadequate cover is invariably associated with areas of high corrosion risk due to both carbonation and chloride ingress. By surveying the surface of a structure with an electromagnetic covermeter and producing a cover contour plot, the high-risk areas can be easily identified. A cover survey of newly completed structures would rapidly identify likely problem areas and permit additional protective measures to be taken.

Cracked Cover

While this remains an ill-defined area, two forms of crack are of interest when evaluating the condition of a reinforced concrete structure; those present before the onset of corrosion which might assist the corrosion processes (large shrinkage and movement cracks), and those produced as a direct consequence of corrosion (expansive corrosion products leading to cracking and spalling).

It should be remembered that reinforced concrete is intrinsically a cracked material because the steel stops the structure failing in tension but the brittle concrete cracks to the depth of the reinforcement. Only those cracks above a critical width which intersect the steel are liable to assist the corrosion processes.

Presence of Chloride Ions

Chloride ions can enter concrete in two ways:

- They may be added during mixing either deliberately as an admixture or as a contaminant in the original constituents

- They may enter the set concrete from an external source such sea water.

Once chloride ions have reached the reinforcement in sufficient quantities they will depassivate the embedded steel by breaking down the protective oxide layer normally maintained by the alkaline environment.

The concentration of chloride ions required to initiate and maintain corrosion is dependant upon the alkalinity and it has been shown that there is an almost linear relationship between hydroxyl ion concentration and the respective threshold level of chloride.

Carbonation

Carbon dioxide present in the atmosphere combines with moisture in the concrete to form carbonic acid. This reacts with the calcium hydroxide and other alkaline hydroxides in the pore water resulting in a reduction in the alkalinity of the concrete. The rate at which this neutralisation occurs is influenced by factors such as moisture levels and concrete quality.

The depth of carbonation in a structure can be quite easily established by the use of phenolphthalein indicator on freshly exposed material. The distinctive colour change, from deep pink in unaffected concrete to clear in the carbonated region, is sufficiently accurate for most practical purposes provided a number of measurements are obtained to allow for local variations.

Environmental Considerations

The microclimate to which the reinforced concrete member is exposed directly affects the likelihood and extent of reinforcement corrosion. Factors such as chloride ion levels and pH have already been discussed but the most important aspect of the local environment is the moisture level. Carbonation, chloride ion ingress, resistivity and corrosion rate are all greatly influenced by the degree of saturation.

4. Summary

- The majority of reinforced concrete structures show excellent durability and perform well over their design life.

- Adverse environments or poor construction practice can lead to corrosion of the reinforcing steel in concrete.

- The major mechanisms for corrosion are atmospheric carbon dioxide ingress (carbonation) and chloride attack from cast-in or diffused chlorides.

- The corrosion and deterioration mechanisms are essentially the same for both carbonation and chloride attack.

- Proper choice of materials, adequate cover to reinforcement, good quality concrete and attention to the environment during construction will enhance the durability of reinforced concrete structures.

Source: Abstracted from Corrosion Protection Association monograph 1

APPENDIX 1: CONCRETE AND STEEL DESTRUCTION

How to Dissolve Concrete

Use de-icers containing fertilizer ingredients such as ammonium sulfate, ammonium nitrate, calcium chloride and magnesium chloride.

These chemicals WILL ATTACK AND DESTROY CONCRETE BY CHEMICAL REACTION.

Working with concrete can be a messy business. While concrete has many wonderful applications and properties, it often leaves behind splashes and streaks and can be difficult to remove. With the right combination of acids and elbow grease, you can remove the left-over concrete. Read on to learn how to dissolve concrete. Does this Spark an idea?

Instructions

1. Put on your goggles, gloves and apron. The muriatic acid that you will use is extremely strong and can damage the eyes and skin. Do not attempt to dissolve concrete without the proper protective gear. Remember to only work in a well-ventilated area.

2. Pour the muriatic acid on the concrete to be dissolved. Allow the acid to sit for 45 minutes.

3. Scrape the concrete with a putty knife or spatula. If the concrete will not come off with a little effort, reapply the muriatic acid and allow it to sit for another 45 minutes. Continue to check the consistency of the concrete every 45 minutes. Do not allow the acid to sit longer that two hours.

4.Rinse the acid and concrete well. Make sure to scoop up any concrete slurry and dispose of it properly to prevent damage to surfaces or vegetation. Make sure you do not allow any bases to come in contact with the acid.

Tips & Warnings

Muriatic acid is also known as hydrochloric acid. It can be found at most home improvement stores or swimming pool maintenance stores.

Always work in a ventilated area. Set up fans to blow the fumes away from your face if possible. Remember to take frequent breaks.

How to Dissolve Concrete With Acids

Concrete is a durable building material that takes special materials to dissolve once it's hardened into place. Phosphoric acid and trisodium phosphate are the main compounds used to dissolve concrete leftover from masonry work. Sometimes, that doesn't do the trick. If that's the case, use muriatic acid, an industrial grade of hydrochloric acid -- but only after washing away the other types of acids and donning all the right safety equipment. Does this Spark an idea?

Things You'll Need

Phosphoric acid or trisodium phosphate

Muriatic acid (if necessary)

Safety goggles, apron and rubber gloves

Instructions

1 .Don your safety goggles, gloves and long apron. Even weak acids can harm your skin and eyes.

2 .Open a box of baking soda and bring a hose to where you're working. You may need these to neutralize an accidental spill of acid. Spray all foliage nearby with water and a powder of limestone -- in case you accidentally spray them with the acid.

3.Spread a plastic tarp over areas like carpet or grass where you don't want the acids to go. Open your windows, if you're cleaning the concrete inside. You'll need the extra ventilation.

4 .Spread your phosphoric acid or trisodium phosphate over the concrete area you want to clean first, using a mixture with water that's recommended by the individual manufacturer. Use a brush to scrub the acid into the concrete. These are weaker acids that just might work to dissolve a sufficient amount of concrete. After these acids have soaked into the concrete for about one minute, scrape the concrete you're trying to dissolve with a sharp putty knife.

5 .Rinse the area with water and inspect it. Decide whether you'll need a tougher acid.

6 .Mix your muriatic acid with water in a durable -- and expendable -- plastic bucket. A common mixture is 10 parts water to one part muriatic acid, but follow the directions on the

bottle you've purchased. Never pour water into the acid; always pour the acid into the water to avoid potential damage from the acid from splattering.

7 .Gently pour the acid mixture over the concrete you want to dissolve. Let it soak for at least one minute, scrubbing the acid into the concrete with a brush. After a minute, try to scrape up the concrete you're trying to dissolve.

8.Rinse the acid and dissolved concrete with water. It should be a fine powder called calcium carbonate.

Tips & Warnings

A sharp utility knife may be a better scraper than a putty knife.

Try a commercial concrete dissolver if you're worried about mixing your own acid compound.

Don't pour muriatic acid into an empty container. This could cause splattering.

Use LIQUID HAMMER

Use LIQUID HAMMER in conditions that will prevent the surface to be cleaned from drying out too quickly. LIQUID HAMMER is most effective when used in shaded areas or during evening hours.

LIQUID HAMMER is best applied using a foaming sprayer. Depending on the sprayer you use, you will get different thickness or qualities of foam.

Apply LIQUID HAMMER generously and wait for 15 minutes or until foam has turned the concrete to a paste. If a paste has not formed, re-apply LIQUID HAMMER. This may occur with heavy buildup or older concrete, which may require several applications and /or brushing. Once a paste has formed, rinse with water and agitate or pressure wash.

Recommended Dilution Ratio

Purpose

Liquid Hammer

water

For Old Concrete

1 Litre

1 Litre

For Fresh Concrete

1 Litre

3 Litre

NB: LIQUID HAMMER will also act as a degreaser at the same time as removing concrete/cement.

What is the strongest chemical to damage cement structure?

Check with a structural engineer. The most damage to concrete is caused by a simple molecule: H_2O.

The surface of concrete can have many tiny cracks. When water enters these cracks and freezes, the ice expands, opening up the crack. Do this repeatedly and the crack gets bigger and bigger, eventually causing permanent damage to the concrete surface.

Next we have common air-borne substances that combine with water to form acidic solutions. The most common are carbon dioxide and sulfur dioxide. Chloride ion, carried along with mist from the ocean or from NaCl and $CaCl_2$ used to melt ice, can react with the concrete, promoting its degradation.

Aside from the freezing and thawing that damages concrete how do you suppose all those nasty acids and chemicals get to the concrete? Of course. They are all dissolved in H_2O.

Of course, I covered those other nasty chemicals as well. The CO_2 in the air won't damage concrete until it has dissolved in water. The SO_3 won't form an acid until it dissolves in water. "Chloride" only exists as an ion in a solution of water. Any acid, HCl, H_2SO_4, etc. is dissolved in water.

There are two main types of concrete degradation. One is a mechanical and the other chemical.

The mechanical one is from water. Most large concrete structures are internally reinforced with iron rebar or similar. Concrete is a porous structure and if it is not sealed properly, water will penetrate the structure. The water will then cause the iron rebar to rust. The problem with this is that when iron rusts it expands to about 9 times the volume (this is from memory; I don't have the reference any more). This expansion puts pressure on the surrounding concrete; eventually cracking the concrete, this is followed by flaking and eventually, if not treated, structural failure. Various chemicals will speed this up, one of the main ones is Cl- ion from coastal areas; but any chemical that hastens the corrosion of iron will speed this process up. This is often referred to as concrete cancer. This is mechanical because there is no direct attack on the concrete, the concrete fractures due to the mechanical pressure applied due to the corrosion of the iron rebar.

Chemical attack is probably H_2SO_4. Although hidden from view to most people, attack by H_2SO_4 is a major problem. The attack takes place in our sewers, where certain microbes feast in the anaerobic environment. on the H_2S gas given off from our effluent. The problem is that after they digest the H_2S they secret H_2SO_4. The H_2SO_4 attacks the concrete directly, dissolving it and liberating CO_2 amongst other things. One new/refurbished sewer system in Sth Africa almost collapsed after 2 yrs due to microbial attack.

HCl will also attack concrete. In fact almost any acid will attack concrete, particularly strong acids. But most strong acids are not found in the environment in quantities that will be destructive. The reason I mentioned H_2SO_4 is that it is a huge commercial issue worldwide. It is also a component of acid rain

Destruction by ice is mechanical not chemical attack; also most of the worlds population live in warm areas (will not freeze) so this is irrelevant to their buildings/structures.

Actually the 'nasties' get in there in there gaseous form as gases will penetrate a porous structure much more readily than a liquid will. Of course things like Cl- need water to penetrate the structure.

Freezing will always be a minor problem as compared to rusting of rebar due to the lower amount of expansion that occurs as water freezes compared to the expansion of the rebar due to rust. Also the freezing will generally require a crack to expand into, which is normally formed initially by rusting of rebar. Also freezing only occurs in higher latitudes where as rusting of rebar is worldwide problem.

Trust me I spent 7 years formulating/designing products for construction, sealing and repairing concrete structures largely due to acid attack and concrete cancer in a temperate climate.

I'm not sure of the strongest chemical, but HCl (hydrochloric acid) will devour cement which is a main component of concrete. We use HCl (we call it muriatic acid) to etch concrete surfaces. It gets diluted at least 5:1 water:acid before it's applied. You can see and hear it sizzle as it eats away the cement.

Do concrete deicers damage concrete? The answer is no. It's the misuse of deicers that causes damage to concrete.

The two most common types of deicers are sodim chloride (rock salt) and calcium chloride. They do nothing when dry, but form a brine when combined with miosture. This brine penetrates down to the concrete and spreads out, melting and breaking the bond between the ice and concrete. There is also heat created when the salts dissolve (exothermic reaction) which facilitates melting.

The common misconception in using these deicers is that you should wait for all the snow and ice to melt. But the proper way is just get the bond of ice and concrete broken, then mechanically remove the rest of the snow and ice with a shovel or plow.

So why not just wait until it all melts? Concrete's biggest enemy is freeze and thaw cycles. Water expands as it freezes. This expansion pressure taking place in the pores of concrete can bust it apart causing spalling. Leaving salt sitting on concrete increases the number of freeze and thaw cycles thus increasing the chance that the concrete will be damaged.

On the package of most concrete deicers, the instructions will tell you to mechanically remove the ice and snow once it is broke loose from the concrete. Not only does that prevent damage, but keeps people from tracking in that unsightly salt residue.

Sulfate attack in concrete and mortar

Sulfate attack can be 'external' or 'internal'.

External: due to penetration of sulfates in solution, in groundwater for example, into the concrete from outside.

Internal: due to a soluble source being incorporated into the concrete at the time of mixing, gypsum in the aggregate, for example.

External sulfate attack

This is the more common type and typically occurs where water containing dissolved sulfate penetrates the concrete. A fairly well-defined reaction front can often be seen in polished sections; ahead of the front the concrete is normal, or near normal. Behind the reaction front, the composition and microstructure of the concrete will have changed. These changes may vary in type or severity but commonly include:

- Extensive cracking

- Expansion

•Loss of bond between the cement paste and aggregate

•Alteration of paste composition, with monosulfate phase converting to ettringite and, in later stages, gypsum formation. The necessary additional calcium is provided by the calcium hydroxide and calcium silicate hydrate in the cement paste

The effect of these changes is an overall loss of concrete strength.

The above effects are typical of attack by solutions of sodium sulfate or potassium sulfate. Solutions containing magnesium sulfate are generally more aggressive, for the same concentration. This is because magnesium also takes part in the reactions, replacing calcium in the solid phases with the formation of brucite (magnesium hydroxide) and magnesium silicate hydrates. The displaced calcium precipitates mainly as gypsum.

Other sources of sulfate which can cause sulfate attack include:

•Seawater

•Oxidation of sulfide minerals in clay adjacent to the concrete - this can produce sulfuric acid which reacts with the concrete

•Bacterial action in sewers - anaerobic bacterial produce sulfur dioxide which dissolves in water and then oxidizes to form sulfuric acid

•In masonry, sulfates present in bricks and can be gradually released over a long period of time, causing sulfate attack of mortar, especially where sulfates are concentrated due to moisture movement

Internal sulfate attack

Occurs where a source of sulfate is incorporated into the concrete when mixed. Examples include the use of sulfate-rich aggregate, excess of added gypsum in the cement or contamination. Proper screening and testing procedures should generally avoid internal sulfate attack.

Delayed ettringite formation

Delayed ettringite formation (DEF) is a special case of internal sulfate attack.

Delayed ettringite formation has been a significant problem in many countries. It occurs in concrete which has been cured at elevated temperatures, for example, where steam curing has been used. It was originally identified in steam-cured concrete railway sleepers (railroad ties). It can also occur in large concrete pours where the heat of hydration has resulted in high temperatures within the concrete.

DEF causes expansion of the concrete due to ettringite formation within the paste and can cause serious damage to concrete structures. DEF is not usually due to excess sulfate in the cement, or from sources other than the cement in the concrete. Although excess sulfate in the cement would be likely to increase expansion due to DEF, it can occur at normal levels of cement sulfate.

A key point in understanding DEF is that ettringite is destroyed by heating above about 70 C.

A definition of delayed ettringite formation

DEF occurs if the ettringite which normally forms during hydration is decomposed, then subsequently re-forms in the hardened concrete.

Damage to the concrete occurs when the ettringite crystals exert an expansive force within the concrete as they grow.

In normal concrete, the total amount of ettringite which forms is evidently limited by the sulfate contributed by the cement initially. It follows that the quantity of ettringite which forms is relatively small. Ettringite crystals form widely-dispersed throughout the paste. If expansion causes cracking, ettringite may subsequently form in the cracks but this does not mean the ettringite in the cracks caused the cracks initially.

DEF causes a characteristic form of damage to the concrete. While the paste expands, the aggregate does not. Cracks form around these non-expanding 'islands' within the paste - the bigger the aggregate, the bigger the gap.

Conditions necessary for DEF to occur are:

- High temperature (above 65-70 degrees C approx.), usually during curing but not necessarily

- Water: intermittent or permanent saturation aftercuring

- Commonly associated with alkali-silica reaction (ASR)

In laboratory tests, limestone coarse aggregate has been found to reduce expansion.

DEF usually occurs in concrete which has either been steam cured, or which reached a high temperature during curing as a result of the exothermic reaction of cement hydration.

As the curing temperature of concrete increases, ettringite normally persists up to about 70 C. Above this temperature it decomposes. In mature concrete, monosulfate is usually the main sulfate-containing hydrate phase and this persists up to about 100 C. DEF could occur in concrete which was heated externally, eg: from fire.

An ettringite molecule contains 32 molecules of water; ettringite formation therefore requires wet conditions.

DEF and ASR appear to be closely linked; in one study (Diamond and Ong, 1994) a mortar made using limestone aggregate was cured at 95 C. Subsequent ettringite formation within the paste was scarce and expansion was minimal. However, if aggregate susceptible to ASR was used instead of limestone, ettringite formation and expansion were both much greater. This, and other studies, suggests that ASR is, or can be, a precursor for DEF expansion.

The effect of cement composition on DEF is not well understood. Some factors correlate strongly but the causes are not clear. In laboratory tests, DEF expansion was shown to correlate positively with cement-related factors, including:

- high sulfate

- high alkali

- high MgO

- cement fineness

- high C3A

- high C3S

DEF is still by no means fully understood. For further reading on this subject, try:

Lawrence C D 'Laboratory Studies of Concrete Expansion Arising from Delayed Ettringite Formation,' (1993) published by the British Cement Association.

Lawrence C D (1995) Cement and concrete research, Vol 25, p903.

Diamond and Ong (1994) in 'Cement Technology' (Ceramic Transactions Vol. 40, p79). American Ceramic Society.

Kelham S, Cement and Concrete Composites, Vol. 18, p171.

Thaumasite form of sulfate attack (TSA)

The thaumasite form of sulfate attack (often abbreviated to TSA) requires a source of sulfate and also of carbonate. Thaumasite can occur rarely as a natural mineral as an alteration product of limestones.

Thaumasite can form in concrete and in mortar. The cement hydration products normally present, mainly calcium silicate hydrate and calcium hydroxide, are decomposed as a result of both sulfate attack and of carbonation. Since it is the calcium silicate hydrate in concrete that provides most of the strength, thaumasite formation results in severe weakening.

Thaumasite has the chemical formula:

$[Ca_3Si(OH)_6.12H_2O]\ (SO_4)(CO_3)$ or $CaSiO_3.CaCO_3.CaSO_4.15H_2O$

It tends to form at low temperatures, typically about 4 C - 10 C. As it forms, the concrete or mortar converts to a friable material often described as a 'mush.' Concrete severely affected by thaumasite formation can easily be broken with the fingers and the coarse aggregate lifted out.

A source of additional water is also required for thaumasite formation. Damp cementitious render over brickwork, especially where the render is cracked, and concrete and masonry in cool, damp cellars are typical examples of where thaumasite may occur.

Normal sulfate attack usually results in the formation of ettringite. This uses aluminium provided by the cement and clearly this is limited in quantity in normal concrete. However, thaumasite formation does not involve aluminium; given an adequate supply of sulfate and carbonate, thaumasite can continue to form until the calcium silicate hydrate is completely decomposed. Consequently, while the use ofsulfate-resisting Portland cement provides some defence against normal sulfate attack, it does not give any particular protection against thaumasite formation.

Sulfate can be supplied from a range of sources; groundwater or bricks are common examples. Carbonate can be supplied from atmospheric CO_2 or from limestone present in the concrete or mortar.

Serious damage to concrete or masonry due to thaumasite formation is not a common occurrence, even in cool, damp climates.

Salt Water Corrosion Effects on Concrete

Did you know salt water was corrosive? It is. In fact it is a problem that engineers have been faced with for some time in regards to larger concrete structures like sea walls. Of course sea walls are corroded by much more than salt, such as sand and gravel kicked up and splashed against the concrete.

Salt water itself contains magnesium chloride, sulfate ions and hydrogen carbonation ions that will essentially attack concrete to a certain degree, but what really starts to corrode in a concrete structure is any of the steel substructure within.

Concrete contains an alkaline environment that provides some protection against corrosion. The steel inside the concrete that is used for reinforcement will react with the concrete and form film that protects the steel.

This is where salt water works against that process. The chloride and sulfate ions will weaken that film as the water soaks into the concrete. Once the film is breached, then the corrosion process begins to work on the steel itself.

Have you ever seen rust stains coming out of concrete? Usually these stains appear around a small fissure or crack. The fissure or crack would have been the most likely place for the salt water to enter.

Because concrete is a type of porous material, oxygen and humidity can be present at the point the salt water has come into contact with the film. This is when the corrosion process of the steel will begin. This is also the point where things can go bad.

Now granted, this is not an over night process. Generally this process is gradual, but environmental conditions can accelerate the process. Building a holding tank for saltwater aquaria risks this sort of corrosion if not properly protected.

Going back to the steel in the concrete, this being wire mesh of rebar, this normally just a simple carbon steel. When carbon steel corrodes, it expands. Have you ever found something old that’s made of steel that has become all rusty? You recognize the item, but it’s usually a lot bigger than it was when it was new.

The problem with the steel inside your concrete tank is that as it expands, forces will be applied to the concrete structure that causes it to crack. This in turn, leads to more of the corrosion process to begin. At some point, if not cared for, the concrete will totally fail.

As I said earlier, corrosion of this sort will surely destroy concrete over time unless it is properly protected. You need a barrier between the concrete and the salt water that will stop water, chlorides and oxygen from reaching the inner working of the structure.

Pond Shield epoxy has been formulated to do just that. It has been tested in a variety of corrosive environments, including salt water to ensure that it is capable of performing this important task of protecting the concrete.

Alkali-silica reaction in concrete

Alkali-silica reaction (ASR) can cause serious expansion and cracking in concrete, resulting in major structural problems and sometimes necessitating demolition. This is a short introduction to ASR - for more information, see the Understanding Cement e-book.

ASR is the most common form of alkali-aggregate reaction (AAR) in concrete; the other, much less common, form is alkali-carbonate reaction (ACR). ASR and ACR are therefore both subsets of AAR.

ASR is caused by a reaction between the hydroxyl ions in the alkaline cement pore solution in the concrete and reactive forms of silica in the aggregate (eg: chert, quartzite, opal, strained quartz crystals).

A gel is produced, which increases in volume by taking up water and so exerts an expansive pressure, resulting in failure of the concrete. In unrestrained concrete (that is, without any reinforcement), ASR causes characteristic 'map cracking' or 'Isle of Man cracking'.

Gel may be present in cracks and within aggregate particles. The best technique for the identification of ASR is the examination of concrete in thin section, using a petrographic microscope. Alternatively, polished sections of concrete can be examined by scanning electron microscopy (SEM); this has the advantage that the gel can be analysed using X-ray microanalysis in order to confirm the identification beyond any doubt.

The conditions required for ASR to occur are:

•A sufficiently high alkali content of the cement (or alkali fromother sources)

•A reactive aggregate, such as chert

•Water - ASR will not occur if there is no available water in the concrete, since alkali-silica gel formation requires water

The use of pozzolans in the concrete mix as a partial cement replacement can reduce the likelihood of ASR occurring as they reduce the alkalinity of the pore fluid.

With some aggregates, expansion due to ASR increases in proportion with the amount of reactive aggregate in the concrete. Other aggregates show what is called a “pessimum” effect; if the proportion of reactive aggregate in test mixes is varied, while other factors are kept constant, maximum concrete expansion occurs at a particular aggregate content. Higher or lower proportions of reactive aggregate will give a lower expansion.

The process of ASR is believed to be in many respects similar to the pozzolanic reaction, such as occurs normally in concrete containing pulverised fuel ash (PFA), for example. However, there is an important difference. In the pozzolanic reaction small pozzolanic particles are reacting in a Ca-rich environment, while ASR occurs in mature concrete and involves larger particles of aggregate.

The pozzolanic reaction mechanism is believed to be a process in which silicate anions are detached from the reactive aggregate by hydroxyl ions in the pore fluid. Sodium and potassium ions are the ions most readily-available to balance the silicate anions and an alkali-silicate gel is formed. This can take up (imbibe) water and is mobile. The alkali-silicate gel is unstable in the presence of calcium, and calcium silicate hydrate (C-S-H) is formed.

In the pozzolanic reaction where a pozzolan is used as a partial cement replacement, the particles are small. As there is much calcium available in young concrete, the alkali-silicate gel forms in a thin layer around the pozzolanic particle and quickly converts to C-S-H. No expansion results.

In the case of alkali-silica reaction, the reaction usually occurs much later, possibly years after the concrete was placed. Large aggregate particles (large, that is, compared with cement-sized pozzolan) generate a significant volume of gel which then takes up water and expands within the hardened, mature concrete.

Because the concrete is mature, calcium availability is limited as most of the calcium is bound up in stable solid phases. The rate of supply of calcium is therefore insufficient to convert the gel quickly to C-S-H. Expansion of the gel as water is taken up, may result in damage to the surrounding concrete. Over time, the gel slowly does take up calcium; eventually the composition of the alkali-silica gel may become very similar to that of the calcium silicate hydrate in the cement paste (see Figure 4). By then, though, the damage to the concrete may have already been done.

In a) the gel spectrum shows large peaks due to silicon and potassium (the alkali) and only a very weak peak due to calcium. In b) the calcium peak has become much stronger and the potassium peak much weaker. In c) the potassium peak has disappeared entirely and the gel has approximately the same composition as the normal calcium silicate hydrate comprising the bulk of the cement paste. Clearly, the gel is older with increasing distance from the aggregate particle in which it originated - the 'oldest' gel has had more time in which to take up calcium from the surrounding paste, and has now become calcium silicate hydrate.

Of course, concrete can also suffer from physical damage, for example through impact, abrasion or frost action.

It should be stressed that concrete which has been designed appropriately for the conditions in which it is used, and produced in accordance with the design, should have a very long service life. That said, sometimes problems do arise. Often, these can be traced back to poor design or workmanship.

Some of the most common causes of concrete deterioration are:

- Cracking and spalling due to corrosion of steel reinforcement

- Leaching

- Sulfate attack

- Alkali-silica reaction

- Carbonation

There are many other forms of chemical attack which can damage concrete, including oils or fats, acid, and salt solutions.

Strictly speaking, carbonation is not detrimental to concrete; in fact the compressive strength of carbonated concrete is higher than that of uncarbonated concrete. However, since carbonation can be closely associated with other causes of concrete deterioration, and involves major chemical changes in the cement paste within the affected concrete, it will be considered here too.

Usually, concrete which is affected by one of these processes will also show signs of others. To take an extreme example, consider a concrete cured at high temperature - this could be a steam-cured concrete or concrete from a large pour where the heat of hydration of the cement has raised the temperature above about 70 C.

In such a concrete, a particular form of sulfate attack known as delayed ettringite formation (DEF) could occur. DEF is often associated with alkali-silica reaction, if susceptible aggregate is also present. Both of these processes induce cracking in the concrete; this may allow water to percolate through the cracks, resulting in leaching. In addition, the cracks will allow carbon dioxide to penetrate deep into the concrete as gas or dissolved in rain water, initiating carbonation at depth within the concrete. If steel reinforcement is present in the affected area, corrosion is likely to occur. This concrete would then be showing signs of all five deleterious processes discussed here.

Carbonation of concrete

Carbonation of concrete is associated with the corrosion of steel reinforcement and with shrinkage. However, it also increases both the compressive and tensile strength of concrete, so not all of its effects on concrete are bad.

Carbonation is the result of the dissolution of CO_2 in the concrete pore fluid and this reacts with calcium from calcium hydroxide and calcium silicate hydrate to form calcite ($CaCO_3$).

Aragonite may form in hot conditions.

within a few hours, or a day or two at most, the surface of fresh concrete will have reacted with CO2 from the air. Gradually, the process penetrates deeper into the concrete at a rate proportional to the square root of time. After a year or so it may typically have reached a depth of perhaps 1 mm for dense concrete of low permeability made with a low water/cement ratio, or up to 5 mm or more for more porous and permeable concrete made using a high water/cement ratio.

The affected depth from the concrete surface can be readily shown by the use of phenolphthalein indicator solution. This is available from chemical suppliers. Phenolphthalein is a white or pale yellow crystalline material. For use as an indicator it is dissolved in a suitable solvent such as isopropyl alcohol (isopropanol) in a 1% solution.

Warning: like all chemicals, phenolphthalein solution should be treated with respect. Both phenolphthalein itself and isopropyl alcohol are harmful and, since it contains alcohol, the indicator solution is flammable. Ingestion, or contact with skin or eyes should be avoided, as should breathing the vapour. Possible effects on the human body include kidney damage and cancer.

The phenolphthalein indicator solution is applied to a fresh fracture surface of concrete. If the indicator turns purple, the pH is above 8.6. Where the solution remains colourless, the pH of the concrete is below 8.6, suggesting carbonation. A fully-carbonated paste has a pH of about 8.4.

In practice, a pH of 8.6 may only give a faintly discernible slightly pink colour. A strong, immediate, colour change to purple suggests a pH that is rather higher, perhaps pH 9 or 10.

Normal concrete pore solution is saturated with calcium hydroxide and also contains sodium and potassium hydroxide; the pH is typically 13-14. Concrete with a pore solution of pH 10-12 is less alkaline than sound concrete but would still produce a strong colour change with phenolphthalein indicator. It therefore follows that the indicator test is likely to underestimate the depth to which carbonation has occurred.

In confirmation of this, microscopy - either optical microscopy using thin-sections, or scanning electron microscopy using polished sections - shows carbonation effects at greater depths than indicated by phenolphthalein indicator. Nevertheless, this test is very useful as a means of making an initial assessment - it is quick, easy and widely used.

Phenolphthalein indicator solution applied to a fresh fracture surface through a concrete slab.

The indicator has not changed colour near the top and bottom surfaces, suggesting that these near-surface regions are carbonated to a depth of at least 4 mm from the top surface and 6 mm from the lower surface. Where the indicator has turned purple - the centre of the slab - the pH of the concrete pore fluid remains high (above 8.6, probably nearer 10). Whether the cement paste here is completely uncarbonated is unclear, despite the strong purple indicator colour; a more complete assessment would require microscopic examination. Indicator was not applied at the right hand side of this image and so the concrete here remains its original colour.

Corrosive substance

DOT corrosive label

A corrosive substance is one that will destroy and damage other substances with which it comes into contact. It may attack a great variety of materials, including metals and various organic compounds, but people are mostly concerned with its effects on living tissue.

Contents

Chemical terms

The word 'corrosion' is derived from the Latin verb corrodere, which means 'to gnaw', indicating how these substances seem to 'gnaw' their way through the flesh. Sometimes the word 'caustic' is used as a synonym but, by convention, 'caustic' generally refers only to strong bases, particularly alkalis, and not to acids, oxidizers, or other non-alkaline corrosives. The term 'acid' is often used imprecisely for all corrosives.

A low concentration of a corrosive substance is usually an irritant. Corrosion of non-living surfaces such as metals is a distinct process. For example, a water/air electrochemical cell corrodes iron to rust. In the Globally Harmonized System, both rapid corrosion of metals and chemical corrosion of skin qualify for the "corrosive" symbol.

Corrosives are different from poisons in that corrosives are immediately dangerous to the tissues they contact, whereas poisons may have systemic toxic effects that require time to become evident. Colloquially, corrosives may be called "poisons" but the concepts are technically distinct. However there is nothing which precludes a corrosive from being a poison; there are substances that are both corrosives and poisons.

Corrosiveness

When discussing the corrosive nature of a corrosive chemical, we are mostly concerned with its damage on living tissue.

Common corrosives are either strong acids, strong bases, or concentrated solutions of certain weak acids or weak bases. They can exist as any state of matter, including liquids, solids, gases, mists or vapors.

Their action on living tissue (e.g. skin, flesh and cornea) is mainly based on acid-base catalysis of amide hydrolysis and ester hydrolysis. Proteins (chemically known as amides) are destroyed via amide hydrolysis while lipids (chemically known as esters) are decomposed by ester hydrolysis. These reactions lead to chemical burns and are the mechanism of the destruction posed by corrosives.

Some corrosives possess other chemical properties which may extend their corrosive effects on living tissue. For example, sulfuric acid (sulphuric acid) at a high concentration is also a strong dehydrating agent[1], capable of dehydrating carbohydrates and liberating extra heat. This results in secondary thermal burns in addition to the chemical burns and may speed up its decomposing reactions on the contact surface. Some corrosives, such as nitric acid and concentrated sulfuric acid, are strong oxidizing agents as well, which significantly contributes to the extra damage caused. Hydrofluoric acid, although technically a weak acid that may not cause noticeable damage upon contact, produces fluoride ions (the actual corrosive species), causing several health problems after being painlessly absorbed. Zinc chloride solutions are capable of destroying celluloses in living tissues and corroding through paper and silk since the zinc cations in the solutions specifically attack hydroxyl groups in other chemicals, acting as a Lewis acid.

In addition, some corrosive chemicals, mostly acids such as hydrochloric acid and nitric acid, are volatile and can emit corrosive mists upon contact with air. Inhalation can damage the respiratory tract.

Corrosive substances are most hazardous to eyesight. A drop of a corrosive may cause blindness within 2–10 seconds through opacification or direct destruction of the cornea.

Ingestion of corrosives can induce severe consequences, including serious damage of the gastrointestinal tract, which can lead to vomiting, severe stomach aches, and even death.

Common types of corrosive substances

Common corrosive chemicals are classified into:

Acids

Strong acids — the most common are sulfuric acid, nitric acid and hydrochloric acid ($H2SO4$, $HNO3$ and HCl, respectively).

Some concentrated weak acids, for example formic acid and acetic acid

Strong Lewis acids such as anhydrous aluminum chloride and boron trifluoride

Lewis acids with specific reactivity, e.g. solutions of zinc chloride

Extremely strong acids (superacids)

Bases

Caustics or alkalis, such as sodium hydroxide (NaOH) and potassium hydroxide (KOH)

Alkali metals in the metallic form (e.g. elemental sodium), and hydrides of alkali and alkaline earth metals, such as sodium hydride, function as strong bases and hydrate to give caustics

Extremely strong bases (superbases) such as alkoxides, metal amides (e.g. sodium amide) and organometallic bases such as butyllithium

Some concentrated weak bases, such as ammonia when anhydrous or in a concentrated solution

Dehydrating agents such as concentrated sulfuric acid, phosphorus pentoxide, calcium oxide, anhydrous zinc chloride, also elemental alkali metals

Strong oxidizers such as concentrated hydrogen peroxide

Electrophilic halogens: elemental fluorine, chlorine, bromine and iodine, and electrophilic salts such as sodium hypochlorite or N-chloro compounds such as chloramine-T;[2] halide ions are not corrosive, except for fluoride

Organic halides and organic acid halides such as acetyl chloride and benzyl chloroformate

Acid anhydrides

Alkylating agents such as dimethyl sulfate

Some organic materials such as phenol ("carbolic acid")

Some corrosive chemicals are valued for various uses, the most common of which is in household cleaning agents. For example, most domestic drain openers contain either acids or alkalis due to their capabilities of dissolving greases and proteins inside water pipes.[3]

1. APPENDIX 2: HOW TO RUST STEEL WITH ACIDS

How to Rust Steel On Purpose

I am trying to get some metal(iron) strips to rust quickly for an application that I am using in my home. I know that there is a type of chemical that will do this, can you let me know what this is, also what type of sealer do you recommend to seal up the metal after this process has taken place. Also, do you know how long the process takes?

I, too, have been researching this question since we are attempting to build a shade structure on our house and want this finish on the roof. We are seeing shopping centers using this look and are assuming that it can't be too difficult to do since builders are using it in quantity. Has anyone tried rusting those 2' x 8' corrugated metal strips? Vinegar and salt sound like the best and cheapest method if it works.

I am an artist that has been using rusted steel canvasses for a few years. What I have found to rust evenly and the most time efficiently is muriatic acid. I use very diluted acid/water mix and apply it to cold rolled steel and within 24 hours the 5x3 foot canvass is pretty covered. For three to four more days I spray the metal down with warm water only (add a little salt to speed things up). The water baths remove most of the acid compound. The metal will continue to rust and pit so you must stop the process at desired aesthetic. I use hydrogen peroxide to stop the chemical process (this is a tip I picked up in an old chemistry book). After I have finished painting, sanding, etching etc. etc. I apply two coats of water based polyurethane. I have sold paintings to people who display them outside on their patios and I have yet to find unwanted rust anywhere on the metal. I would also advise recoating with clear coat every few years.

Simple - Pool CHLORINE. Cheap @ $2.50 a Gallon.

Pour Chlorine in a "clean" spray bottle and use away from concrete or anything you don't want to destroy! I shouldn't have to tell you but please don't mix anything with this and BE CAREFUL wear protective gloves do not breath in fumes while spraying on product. Read the handling instructions. this stuff is a nasty product. be sure to remove any oils or greased.

Depending on the vintage-ness or amount of rust you desire. this will produce quick rust with in hour. reply let dry & repeat.

I am building 3 automatic mild steel gates for a state park and they are required to have an actual rust finish. I am grateful for all the postings on this subject. I am under a deadline to perform so can't wait too long for results. The sea salt and vinegar sounds too long. I would like to try the electrolysis method but the gates are 24 feet long and they won't fit in my bathtub! Therefore I will opt out for the pool chlorine method and hope it works as fast as reported. I am having the gates and gate posts sand blasted tomorrow after which I will try and rust them fast. It is true by the way that passing electricity from electrodes through a brine solution (called cracking) produces chloride gas which is lethal to humans; don't try it in your bath tub!

This is a recipe us crafters use to make safety pins, and bells rust for our dolls and things

This concoction will nicely rust all those safety pins, jingle bells, or anything else you want to 'age' for your primitive creations. Do this outside in a safe place (away from children or pets, of course).

In an old mayo jar, combine:

1/2 cup of cider vinegar

1/2 cup of Clorox bleach

1 teasp. of salt

Add your pins or bells and cover loosely. Place in a safe spot and let it sit for about 2 days. Some ladies get desired results in about 2 hours, but I like them super rusty, so I've always left them for about 2 days.

When they are ready, take an old plate (one that you only use for this project from now on) and line it with a couple layers of paper towel. Remove pins or bells with an old fork - again, one you will never use at the dinner table again, and place them on the paper-lined plate. Put the plate in a safe & sunny place. The rusting will occur as they dry. You can swirl the plate periodically to reposition bells so they dry underneath also. It will take a few hours.

IMPORTANT NOTES:

*When ANY acid (such as vinegar in this recipe) is mixed with household Bleach (of any brand name) there is a rapid production of Chlorine Gas, an EXTREMELY TOXIC, even DEADLY gas. If using this recipe, please do so outside on a breezy day and do NOT breathe the air downwind of the mix. Wear safety glasses, as this can be an explosively fast reaction that creates some splashing. Repeated exposure to Chlorine Gas will do serious damage to your lung tissue.

Here's another way to do it

1 pint hydrogen peroxide

1/4 C. vinegar

2 Tbs table salt

Mix together in a large plastic bowl, and then add your metal items to rust. They should start turning the solution brown in an hour or so, but you can leave it overnight if you wish. Take your items out of the mixture, and then lay them on a newspaper or stack of paper towels to dry out in the sun. They will continue rusting as they dry. Feel free to cut the recipe in half or double it according to your needs.

From what I have read, the pool chlorine looks like it is the quickest solution for obtaining a rust finish. My question is that I am trying to rust a Garage door that has been covered with some kind of metal(it seems like it is metal that is used for automobiles). The surface is painted so I do not know if the chlorine will work.

If you have any paint (or primer) on the metal surface you'll need to completely strip it off and get your object back to the original condition. You can proceed from there.

Here's a tip I haven't seen posted here. I got rusted and pitted steel in just a few minutes by mixing bleach with brake/carb cleaner.

Dangerous and too fast. After reading this site, I am now going with a salt/vinegar blend.

I have a technic to make a metal looks rusty.

You will need a rust look paint and industrial (talc - talcum powder)

1 - Give one hand of paint to the metal

2 - While its not dry, apply the talc powder to the zone you painted. That will give you a rust texture.

3 - Apply other hand of paint.

Repeat this process to make the rusty texture as you like.

I used the muriatic acid solution to eat off mill scale (didn't have a sand blaster). I then used the Hydrogen Peroxide and salt.... periodically re-applying. Worked great and in two days I was done.

I have a small business (with big business dreams) that makes metal art, we're new, I just tried my very first time to rust mild steel, I bought a bottle of vinegar at the grocery store, a spray bottle at depot, sprayed the steel, waited ONE HOUR and then heated it from a distance with a rose bud - oh, I used a 24 grit sanding disk first to create a pattern - worked awesome - then sprayed a clear finish over that - very pleased -

Hello thanks for all of the great advice on this page. I am a Sculpture major that mostly works with steel and 80% of the time I rust it. I thought that I should let you all know that for achieving a rusted look over night I use a mixture of salt and hydrogen peroxide sprayed on with any spray bottle and then use a blow torch to heat it. Repeat these steps until you are satisfied, make sure to wear a respirator but so far I have always loved the results that I get with this technique.

I'm a sculptor working primarily in mild steel. I rust much of my work and use a fairly simple solution that's comprised of relatively easily obtained parts.

I first sandblast the work thoroughly - ideally with an abrasive medium to really tear at the surface as opposed to a bead shot which actually closes up the surface of the steel making it more difficult for the rust to adhere (either one will work).

supplies:

Vinegar

Distilled Water

copper sulfate

I heat the water in a pot - add copper sulfate until the water is bright blue (maybe about a 1/2 -

1 cup per gallon? - I'm sure my mixes vary and it always works). Once the water has dissolved the copper sulfate I pour it into a pump sprayer and add vinegar. I usually add about 1/2 as much vinegar as I have water. I'm sorry that I'm not more scientific but it's never really mattered.

Once the piece is sprayed with the solution you will notice a change immediately. First the piece will look like copper (within a couple seconds) and then it will begin to darken and rust. It really doesn't take long to get a nice dark rust. You can reapply again and again to continue the process. It's definitely best to allow it to dry in between each spray down as that is when the oxygen can get to it best and do its job. When the desired rust is achieved (and it's not just powdery surface rust) I rinse it well with water and allow to dry.

.We need to :

1. Find something that will rust steel.

2 find the quickest way to stop the oxidation when it gets to the point we like.

3. find what we can use to seal the steel with after the corrosion is finished so it doesn't rub off onto clothing.

Therefore: Sandy Salt + Moisture = Rust

I am an artist who works with steel and like many of you have the need to have a rich rusty look but where it will not rub off.

On pieces that will be indoors...I have used distilled vinegar and water putting on many layers until I reach the desired look. I then coat it with several coats of satin polyurethane.

What I have found that works best is to use 1/2c root killer (copper sulfate) and mix with 2 cups muriatic acid until dissolved. Pour into gallon jug and fill remainder with water.

Spray this onto your clean metal (the oil must be removed) and then either immediately, or whenever, you can spray with a diluted bleach (can be chlorine) solution.

You will instantly see the reaction of the two chemicals and can tweak the look with misting of water. Or, if you live in a humid climate, you can forgo the bleach spray.

In response to rusting metal. I do much work in the Telluride area and have rusted barn tin for many custom homes. It is very simple. I mix 50/50 Muriatic acid and water. Mop it on with an old rag mop, let sit over night, sometimes two nights, then rinse thoroughly. Many suggest cleaning the metal first for an even look, which is true, but I find the uneven rusting brings out a more natural patina in various shades. Evenly rusted metal looks fake to me, as do many of the metal roofs in Telluride. if I want to expedite the rusting after the initial application, I just spray salt water made with sea-salt over several days. Our ever-changing weather always ensures the chemicals are washed off fairly soon.

Hello, I am a master German painter. Here is how you rust most any metal and then prevent it from rusting further and also make a very nice finish and bring out some natural color from the rust:

1)Urinate into a clean spray bottle.(5 tablespoons of urine will do).

2) For every 5 tablespoons of Urine, pour twice that amount of hydrogen peroxide into the spray bottle.

You now have your magic solution.

3) Wipe whatever you are trying to rust with XYLENE to clean it and remove anything that might inhibit the oxidation process. Let the XYLENE dry completely.

4) Spray your magic solution generously onto the metal, let dry, repeat, let dry, repeat, etc... until you get the amount of rust you are looking for.

I generally spray it and leave it outside overnight. leave it out in the rain, snow, whatever. These are all good things.

5) When you have the amount of rust you want, wipe it down with a clean rag.

6) Spray it with lacquer. Two coats. Make sure it's a real lacquer that is a lacquer thinner base. M.L. Campbell pre-catalyzed lacquer works great or any other lacquer that is a true lacquer(not water-based!)

Note: You can use something else if you want(metal etch, muriatic acid, vinegar... but I use urine because I get a distinctive color in the end that looks better than these other methods.

We have customers who want to seal rusty metal but need to rust it first. I was given a recipe for rusting metal that is safe and inexpensive.

Spray the metal with vinegar (any kind will do)

Then, immediately spray again with hydrogen peroxide. Use 2 different spray bottles or sprayers.

Let dry and repeat several times a day and within a few days you have rusty metal.

Everbrite will seal rusty metal and will allow the rust to show through. The metal must be completely dry and the loose rust removed for good adherence. There is a Satin finish available that many people prefer.

Causing rust is easy...the fastest way I have found is pool chlorine or lemon oil, depending on the look you want.

Halting rust is also easy...I found a marine product at ACE Hardware called Ospho. It is cheap and goes on like water and will completely stop rust. The process takes a while and some "blue" may appear but can be removed with light brushing. Best to let dry for 2-3 days until brushing.

Hello All, getting excited about finishing my first cuts of metal art with a rusted finish. I went and bought some hydrogen peroxide (I read on the web that will cause rust), that didn't work, I tried vinegar, that didn't do anything either.

What am I missing here? I took my metal piece, cleaned it, I even tried heating it. It is cold rolled steel, then I took sand paper (about 150 grit) and rubbed the surface and tried both methods again - just tiny tiny rust spots.

Is there prep work to the metal that I should be doing that I might not be to get these pieces to rust? It shouldn't be this hard from what I am reading? HELP!

Why are my pieces not rusting?

You might want to double check that your "cold rolled steel" isn't stainless steel. Is it very strongly magnetic?

It isn't stainless steel, it is cold rolled I verified from the person that cut it for me, it is thicker - about 12 gauge - but it can't be this hard. Everyone here makes it sound like their pieces rusted so easy? I used combo of vinegar and hydrogen peroxide last night, sprayed on in coats, woke up this morning with just one tiny little spot of color?

I am going to try your method for creating rust, I'm wondering if the outdoor temp is an issue. I will be doing this inside an old barn. I figure that the cold weather will make the process slower, and take longer for it to evaporate. I want to rust a 5'x9' sheet of milled steel (24 gage). How much of the solution do you need to for an area that size? Also, will the solution be alright in a container over a number of days? I figure this will take a while.

i mixed bromine, a common hot tub sanitizer, with water in a spray bottle. then sprayed it directly onto my steel and I got big time instant rust so watch your amounts. no soaking overnight or anything like that, it is truly instant. make sure your area is well ventilated though as it can be strong smelling.

Once a level of distressing plus oxidation are achieved, the finish can be preserved with 4 ought steel wool and mineral spirits (or turpentine if cost no problem) and furniture-floor wax.

The idea is that the steel wool and mineral spirits take the rust deeper into the surface and the spirits redistribute the rust that the steel wool removes. The spirits gets rustier as the wool is repeatedly dipped in a small bucket of it. Rub the entire piece down two or three times with the increasingly rusty steel wool and spirits, let dry.

Use a rag to apply Johnson's floor wax, and other clean rags to buff it back off.

The resulting, low luster finish will last decades if not in the weather or near sea coast.

Work with rubber gloves, in a well ventilated area, away from a source of ignition.

Okay, rust is a popular finish here in the desert, and I've done numerous jobs that required fresh steel to look old. Here's what I do.

To rust galvanized, you first must get rid of the galvanizing --muriatic acid is the best thing for this. Whatever way you apply it, wear gloves, goggles, and a respirator (the cartridge kind NOT a dust mask!) If you don't have or can't afford a respirator, stay upwind and hold your breath, the fumes are nasty. Muriatic acid will also etch concrete, stone, and glass and will discolor wood, so cover these surfaces with plastic if you can't get far away from them. I only do this procedure outdoors in a spot where I don't want any plants to ever grow. The acid can be sprayed (although any metal parts in the sprayer will be sacrificed), wiped, brushed, or spotted onto the surface depending on your desired effect. Let it do it's thing; and when it's done fizzing, rinse the metal with plenty of water.

Now, to rust!

If you've already done the acid wash you're ready- works on any steel, btw. If not, degrease your metal some other way. A light sanding helps too --you want the metal to be as clean and receptive as possible.

Mix:

2 parts vinegar- any kind as long as its 5%

8 parts hydrogen peroxide

1 tsp salt per 18 oz. of mixture

You don't have to be a chemist- the exact proportions aren't critical.

Mix thoroughly.

This is best applied with a spray bottle or pump sprayer, but can be brushed on too. Keep in mind that the initial rust that forms is very delicate and easily removed if you brush too hard or have too much acidity in the mix. You should see a light coating of rust forming immediately. Keep at it; I usually do 5 to 6 applications minimum, letting each dry, rotating the piece while touching it as little as possible. Keep applying until you get the desired depth.

Go to bed. The next day you should have well-set rust.

To seal it, mix:

1 part OIL BASED polyurethane

1 part boiled linseed oil

1 part turpentine or mineral spirits

Rub it in well- until no excess sits on the surface. You'll be left with a semigloss sheen that will fade over time.

Q. I am trying to get the engine stamp pad, which is located on the engine block, right in front of the right side (pass. side) head, to look aged and slightly rusted. Some have suggested coca cola, vinegar, and even salt water. What would be the best process for the result I am looking for? Thanks for any help.

Haven't done it, but I'd probably try a bleach bandage. Bleach is very tough on iron and steel.

By a "bleach bandage" do you mean taking a small piece of cloth, dipping it in bleach, and than placing it on the stamp pad and letting it sit there for awhile. The pad is about 3/4" wide by about 4" long.

Yes, that's what I was thinking.

How to rust steel on purpose

Q. My company provides high quality doors and windows for custom homes. Being in the mountain / mining region, rusted steel is the preferred finish of choice for many surfaces in the home. My question relates to making new steel look old. What is the best, safest, time efficient way to rust raw steel? Then of course, what is the best way to stop or slow down the process and seal the finish as to not present a problem with peoples clothing etc. coming in contact with the steel. Then what might the process be for rusting galvanized? Thank you for your help.

Assuming that #4 is correct, could you please dumb it down a few notches and tell us how to make steel rust? Is it acid? Is it alkali? What is the cheapest and most commonly available chemical to accelerate the rusting process? Table salt? Vinegar? Pool acid (muriatic?)? Some SAFE combination? What do you recommend on large projects (300' of "wrought iron fence)? Architectural elements? Again, assuming that I am just ignorant, metal which I DON'T want to rust does so for free, why should it be expensive to help the process along? I understand that time is money but it shouldn't take twice the national debt of Bolivia to make steel rust. Or is the answer #1 you really don't know?

A. I have "rusted" steel Bimex hinges (3" x 1") to make them look old as follows: Soaked them in metal edge^etch for 2 hours followed by rinsing and vinegar soak overnight. Then rinsed and placed in hot salt water solution overnight. Removed and left to dry. Rust had started to form. Then occasionally sprayed them with water to increase the rusting process. Satisfied with rusty look results at end of 2 day total process. Can't see any reason why larger objects would not work with modified process.

Metal Clean and Etcher

A. Metal edge^etch is a metal etching solution I found at a hardware store. I have since "rusted steel on purpose" without this step. A vinegar soak overnight, Hot concentrated salt solution, and removal of the steel from the salt solution and allowed to dry in the air overnight. An occasional spray with water will speed the process. There is enough salt left on the steel from the hot soak. Finally wash in water, dry (blow dry) and a clear finish if desired. Results have been good and consistent.

Q. I'm replicating furniture handle for rustic living room cabinet. The original pieces are made of steel or iron wire and are fashionably rusted. I've managed to recreate the shape and size, but how do I rust it quick! In few days instead of weeks?

A. I make large quantities of rust for thermite using two different methods (depending on the quality of the steel that I'm working with):

Method 1. --------- You'll need a source of DC electricity, a tub of water and some salt (maybe a tablespoon). Connect a piece of steel to the positive output from your DC source, stick that in the water, and then stick the negative output into the water (but don't let the two touch). Switch on your power supply and let it sit, I usually do this overnight. Make sure you unplug your power supply before attempting to get at the sweet rust meats inside (I think this goes without saying). BE CAREFUL NOT TO ZAP YOURSELF!

Alternatively, you could file the metal down to a nice fine powder, and as suggested above, place in vinegar water, and then warm salt water. As I mentioned before, I use the resulting rust powder to make thermite, which I then use to cast into "permanent" moulds for casting aluminium and various other metals, though I reckon if you were to mix this powder up with some varnish, you'd have a nice "rust paint" to work with. My biggest concern, as you expressed, would be the rust contaminating "healthy" metal. Unfortunately, I don't know how to solve that, but hopefully mine and the others' information has brought you halfway there!

A. I am not the expert you guys seem to be. I have found that by soaking a piece of plain steel 10xx series in hot pure orange or lemon juice you can put a very nice dark tarnish on a knife blade. This makes it not only look old and antiqued but it prevents any future rusting from occurring. Maybe this method will give you some other ideas. It does a great job of anti-reflectiveness on field knives.

A. I recently had a project that required that the sculptured steel have 100 year rusted appearance.

After a lot of research and trial & error & error & error I finally found the right combinations to create 100 years of rust in two day process. I'll start with the chemicals, the amounts will very depending on your surface area. I'm basing on 4' x 4' x 1/4" steel both sides.

Chemicals:

1 gallon Distilled Water

1 pint MEK / methyl ethyl ketone

2 pints muriatic acid

1 half gallon Hydrogen Peroxide (Semiconductor Grade)

1 Cup Sea Salt, Course (Table salt has Talc and will affect the final look)

1 Cup Iron Filings or Ferric Oxide

Tools:

1 Pair PVC protective gloves "Acid resistant"

1 Box latex gloves

2@ 2" to 4" PVC paint brush

1@ 2 gallon plastic bucket

1@ Plastic Spray Bottle

1@ Pizza Cheese Shaker

1@ Water Hose

Preparation:

1. Have your target steel sandblasted to raw metal with an even texture.

2. Find a well ventilated area with access to a water source and drain attach the hose to the water source.

3. Mix equal parts Sea Salt and Iron Filings into the Pizza Cheese Shaker.

4. Fill the plastic spray bottle with Hydrogen Peroxide set the spray pattern to mist and store in a cool dark place until needed. Use Latex gloves; this will burn your skin fast.

5. Lay the intended rusting surface face up and flat. Using rags use the MEK / methyl ethyl ketone and clean any oil, dirt off the surface of the bare metal.

6. Mix the Muriatic Acid and Distilled Water in the plastic bucket and let rest "Cool" be sure to use the PVC Gloves.

Process:

1. Using the mixed Acid and paint brushes heavily coat the surface of the steel and let stand for 15 minutes.

2. Using the water hose rinse the Acid mixture off the surface of the steel.

3. While the surface is still damp sprinkle the Sea Salt & Iron evenly over the surface of the steel.

4. Spray the salted surface with the Hydrogen Peroxide and watch the rust form allow it dry and repeat steps 3 & 4 until you achieve the desired finish.

5. Allow surface to dry thoroughly and continue to the next desired surface.

Q. I need to have a rusty finish on my small old truck models without using commercial compounds

Hey I saw someone post a question about rusting old model cars. Well, I am trying to do the same it seems the vinegar and clorox bleach isn't working just yet but I'll keep trying; my cars are diecast so it may take more than two days. Hmmmmm anyone have any ideas?

I don't know about Mostafa's truck models, but your diecast cars are made of zinc, not steel. Although zinc will corrode with white pits and pockmarks, it can't ever turn to rust. You would need to use an iron patinating solution if you want rust.

I am an architect/builder researching aging and/or getting a patina of rust on steel and was amused by the dialogue to/from the fellow from Telluride, CO. I, too, am doing a high end house in the mountains, and will be using rusted steel in several applications, including the front door.

Those of you in the business of preventing rust, corrosion, and the apparent aging of materials used in construction have to indulge us on this issue. Telluride, like many areas of Colorado and the west has a rich history of mining, logging, and other industrial activities that are preserved (?) in the old buildings that have survived the years but are ravaged by the elements . . . rusty tin roofs and hinges, wood weathered to a light grey, paint faded where sun and rain have worked on it over time, etc.

For new construction many architects, builders and owners want to recapture the look of these materials without actually using old materials.

In my case, I want to install some rusted steel column covers and a large panel over a fireplace in a house that we are building in the mountains for a client. I have a sample of a piece of steel that has been artificially rusted that is beautiful! (sorry, guys!) the fabricator used a thin sheet of hot rolled steel and misted it with vinegar and then sprinkled salt onto it and let is sit for several days, lightly misting it to keep it moist. The color is a rich, mottled rust orange, but the surface is powdery and very fragile, so we still have the problem of "fixing" the color to the base metal so that it doesn't rub off.

I wonder if the one writer meant to say METAL ETCHANT rather than "METAL EDGE" . Etchant is also available from Radio Shack, although it is a nasty chemical and the directions need to be followed.

Adios!